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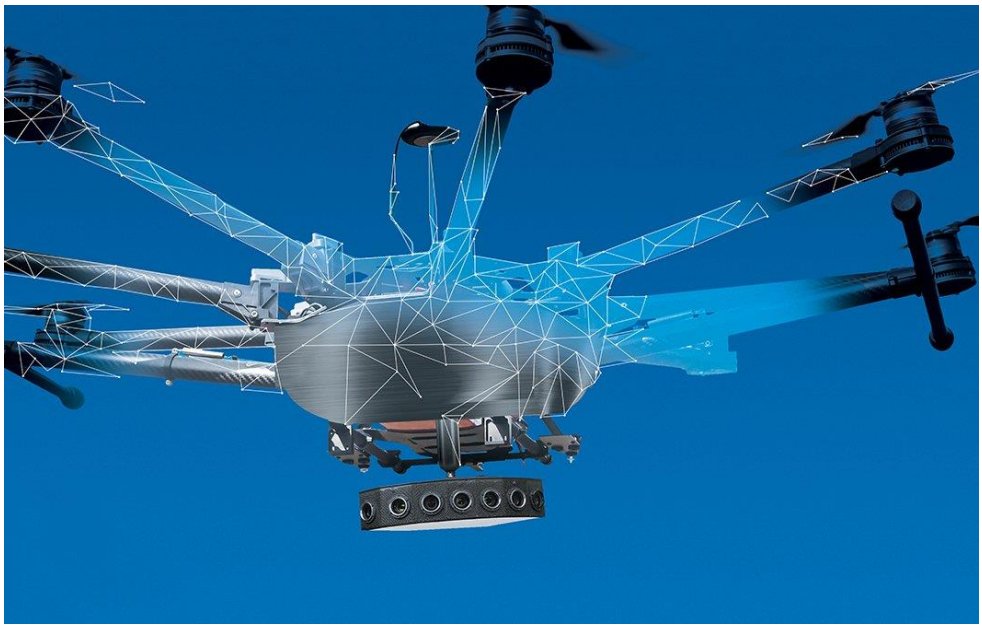
Transport Canada RPAS R&D Yearly Progress Report

LTR-SMM-2020-0064



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Date: March 2nd 2020

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Record of changes

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Introduction and objectives

The project was designed to support Transport Canada (TC) with its mandate to develop policy, regulations, guidance, procedures and airworthiness in support of safe integration of RPAS into the Canadian airspace. NRC is providing consultative Subject Matter Expertise to support this R&D initiative. In the project scope is also for NRC to participate in scientific or technical working groups and peer reviews to support RPAS regulation development.

This document provides an overview of the R&D activities that were performed during Fiscal Year 2019-2020 as part of TC's R&D plan. At a high level, the objectives are:

- Support TC's RPAS regulatory framework development by planning, coordinating and conducting R&D to identify technology advancements, testing, and certification that will enable safe integration of RPAS in the national airspace. This will provide TC with the impartial external SME that will foster stronger and safer RPAS industry in Canada (as per NRC mandate)
- NRC will coordinate the RPAS research activities with Canadian universities and industry and collaborate with international partners as required to generate scientific/technical data to support regulatory framework development while collaborating with other authorities and research organizations to optimize and harmonize results. This will help TC optimize the research effort deployed on its needs. The activities range from project ideation to execution and NRC'S role will focus on technical support, recommendations, and peer review.

Specifically, during the current fiscal year, the NRC contribution has been:

- Provide support, in the high priority R&D sectors, from technical RPAS Subject Matter Expert with several years of R&D/engineering experience
- Plan and coordinate R&D as research progresses, and other research activities are identified and projects must be ideated, scoped and launched.
- Technical strategic planning and coordination of research efforts including development of selected research statement of work and participation in identification and selection of research organization.
- Establishment and/or Participation in selected technical working groups, seminars peer reviews and workshops
- Participation in national calls for projects, with partners, to stimulate research in the RPAS sector

The following image shows the R&D Structure that had been put in place between previously and defines the main interactions in the ongoing research effort.

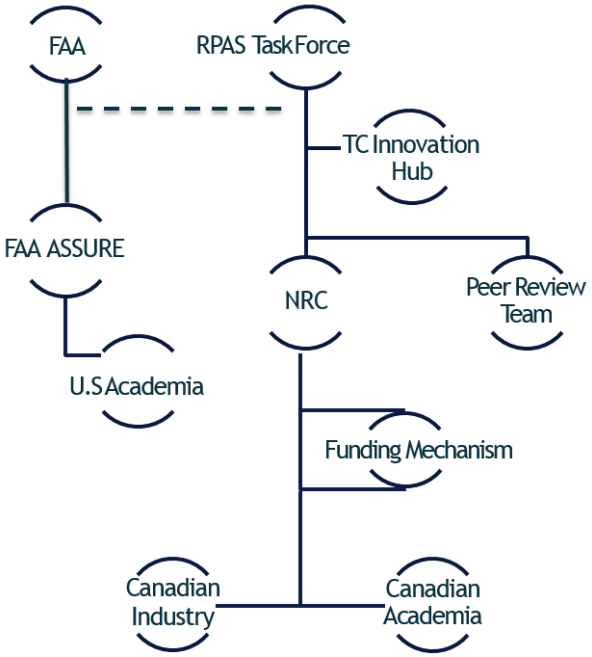


Figure 1 R&D structure

The long term strategic collaboration between NRC and TC is highly valued for the future of the RPAS sector in Canada, since:

1) NRC has unique and highly valuable RPAS technical expertise developed in the course of the Civil UAS program (2013-2019), and is continuing to grow as part of the Integrated Aerial Mobility program (2019-2026), which is very important in order to scientifically support RPAS BVLOS and RTM Regulatory development. NRC's support in R&D planning and coordinating research activities for the next 5 years is critical to the RPAS TF for developing adequate regulations to enable a safe and strong RPAS industry in Canada, as it evolves from BVLOS, to cargo deliveries, to passenger drones.
2) NRC's network is very useful in order to enhance engagement with academia, the industry and international partners;
3) NRC researchers have unique, long standing and advanced technical expertise in Canada and provide highly valued contributions to the TC RPAS TF to help TC shape current and future Canadian RPAS regulations.

For the regulator, the advantages to the R&D dimension consists of the following:

1. Allows maintaining and improving the regulator scientific and technical skills, contributes to its independence and helps to build public confidence in the regulatory system.
2. Allows managing safety and uncertainties (unknowns) of new technology. Thus, R&D is necessary for the identification and characterization of uncertainties as well as for the understanding of their safety relevance.

3. The regulator has a continuing role to review the safety case, which has to be regularly updated to remain an adequate basis for making decisions throughout the implementation of new technologies and use cases. The review aims to determine whether the safety case has been developed to an acceptable level in terms of quality and confidence in safety to move to the next phase.
4. These activities are therefore more a “complement to” and a “verification of” than a“ duplication of” the R&D activities performed by the industry

The objective of the research can be described as follows;

1) Inform development of regulations based on a foundation of scientifically credible data;
    a. Developing R&D and Test and Evaluation criteria
    b. Sponsor test and evaluation of potential technologies and designs that allow for automated or built in compliance with regulations
    c. Identify potential technological solutions to address risks and hazards associated with safe integration of UAS into the national airspace
    d. Identify technology gaps and R&D strategy for Canada leveraging domestic capabilities and international collaborations to obtain the best return on investment for R&D budget, ensuring to avoid duplication of R&D efforts
2) Remove uncertainty for the industry by helping supporting the development of a clear regulatory framework
3) Foster collaboration between industry, academia and government
4) Position Canada as a leader in the RPAS sector at global stage

It should be noted that since CAR Part IX has been implemented, the ongoing research activities aim mostly at supporting regulatory development for Beyond Visual Line of Sight (BVLOS) operations and RTM, while still supporting updates to the VLOS regulatory framework, standards and guidance material, as well as identify longer term needs for Next Generation RPAS.

Research areas and Project overview

In the R&D plan were established seven short term research areas and more long term research areas, as listed below.

Short term research areas

1- Air to Air collision probability and severity
2- Air to Ground (People) collision probability and severity
3- Detect and Avoid
4- RTM (including radio signal integrity)
5- Icing and extreme weather
6- Human Factors
7- Certification of Autonomous Systems (Longer term)

Longer term research needs were also identified, although research on these subjects hasn’t started yet.

Medium/Long term research areas

- Reliability Studies
- Cybersecurity
- Electrical Propulsion
- Software Certification
- Adaptive Intelligence
- Detection and countermeasures
- Noise Certification
- Engine Ingestion
- Precise location and navigation

The following image shows the correlation between IAM research activities and TC research needs.

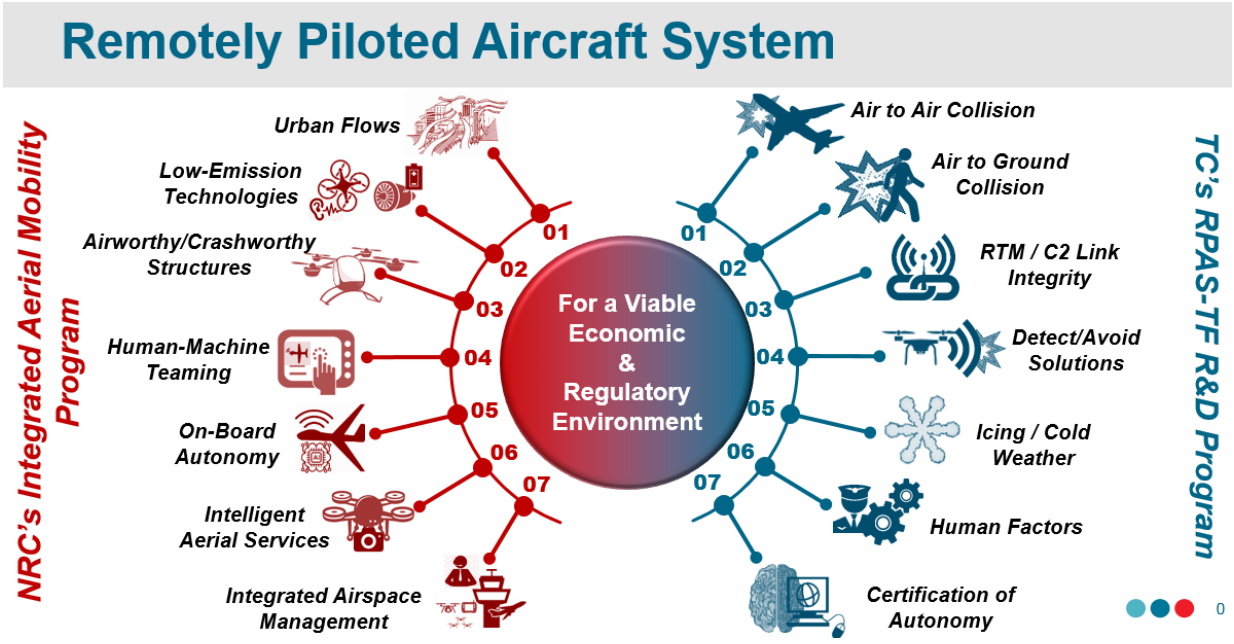


Figure 2 IAM and TC research focus

The following table gives an overview of the projects associated with each short term research area. Detailed information on current projects is provided in the subsequent sections of this report. The objective of this section is to facilitate tracking of research projects. The following table lists the projects and their status.

R&D support Regulation development project list					
Research area	**#**	**Projects**	**FY18-19**	**FY19-20**	**FY20-21**
Air to Air collision probability and severity	**1.1**	Air Risk Model			Initiating
	1.2	Drone Impact Assessment (Drone cannon and impact testing)	Initiated	Continuing	Continuing
Air to Ground collision probability and severity	**2.1**	Human Injury Probability (One project starting under CRIAQ)		Initiating	Continuing
	2.2	Human injury Severity		Initiated	Continuing
Detect and Avoid	**3.1**	DAA system testing (In collaboration with LookNorth)		Initiating	Continuing
RTM	**4.1**	C2 and RTM (One project starting under CRIAQ)		Initiating	Continuing
	4.2	RTM Research			Initiating
Icing and extreme weather	**5.1**	Investigation of effect of icing on Small rotors	Initiated	Continuing	Continuing
	5.2	Investigation of effect of wind in different environments			Initiating
Human Factors	**6.1**	Enhanced Situation Awareness	Completed		
Certification of Autonomy	**7.1**	Certification of autonomous systems (Bell 412)	Initiated	Continuing	Continuing
Planning and coordination	**8.1**	R&D plan development, coordination and update	Initiated	Continuing	Continuing

Table 1 project tracking table

Air to Air collision Probability and Severity (1)

Initial consultations had generated the following problem statement and unknowns, to solve via research:

- Lack of reliable risk analysis that captures:
  - The probability of air to air collision of a UAV to a manned aircraft (lack of data)
  - The severity and damage characteristics due to impact with different categories of drones
- No established guideline for drone manufacturers to minimize potential damage
  - Objective would be for impact physics that resemble a bird strike. Need to establishing design standards for frangibility
- Risk reduction and acceptability

Air to Air Collision Probability Project

NRC and TC are currently initiating a project to do the modeling of Canadian airspace and evaluate collision frequency risk by simulation (FY 20-21).

Air to Air Collision Severity Project

NRC, in collaboration with TC and DRDC, has designed, built and commissioned the “Drone Cannon” in the current fiscal year. The drone cannon facility enables launching typical 1.2kg drones at speeds up to 300 knots, which covers the takeoff or landing speeds of commercial aircrafts. This facility will be utilized to test on real aircraft parts, the damaged caused by a mid-air impact of a commercial aircraft with a drone. 3D printed plastic drones were made to be used as projectiles during commissioning.

At the time of writing this report, the next milestones of the project is impact testing on aircraft component impact.

Air to Ground (People) collision Probability and Severity (2)

Initial consultations had generated the following problem statement and unknowns, to solve via research:

- Probability of collision to the head of a person
- Type of human injury likely to be caused by UAS in potential incident
- Guidelines for drone manufacturers to minimize potential injury
- Risk tolerance definition

Human injury probability project

A project is at the early stage of starting, sponsored by CRIAQ. Below is the project overview available from the CRIAQ website(https://criaq.aero/en/projects/).

"This project seeks to develop an innovative tool to support both the design and the evaluation of regulations and certification processes for single and multidrone technologies. The proposed solution will offer user-friendly functionalities to run drone operations within an ultra-realistic 3D simulator, allowing regulators to assess the impact of proposed norms and rules in terms of human risks, as well as UAV solution providers to validate the conformity of their proposed solutions in relation to those norms and rules. The new tool will be built as a plugin of the Hyper-X-Space (HXS), the open innovation platform for rapid development of multi-drone and multi-agent solutions provided directly by Humanitas Solutions. Five main project objectives have been identified:

Design and implementation of 3D protocols and scenarios for the automated assessment of human and critical infrastructure risk probabilities. Great attention will be devoted to the evaluation of standards and mitigation strategies associated with positioning and navigation systems, as well as UAV control interfaces, possibly powered by Augmented Reality (AR).

Development of the HXS plugin for automated human risk assessment, including specialized functions for monitoring and analysis of metrics of interest, as well as for dynamic scenario configuration. Design and implementation of a new HXS library dedicated to the dynamic modeling of the human agents and the vehicles that will populate evaluation scenarios. Development of a plugin for real-time integration with air traffic data. Production of a preliminary assessment report to be sent to the regulator (Transport Canada).

The project involves 4 industrial partners and 2 academic partners: Humanitas Solutions will provide and develop the 3D evaluation platform HXS; Elisen Associates will offer its expertise in airspace system certification and regulation to support regulation analysis and protocol design activities; Ciena will collaborate on the analysis of ethical impact of autonomous systems and AI solutions (such as privacy and security); École Polytechnique de Montréal will contribute to R&D activities related to simulation and artificial intelligence themes."

Human injury severity project

A project was initiated in collaboration with University of Western Ontario. The first phase of the project involves developing an injury criteria for more vulnerable population than 50th percentile male,

corresponding to 5th percentile female, via simulation. The second phase of the project involves combining Brain Injury Criteria and Head Injury Criteria to define injury thresholds utilizing female, male and 3 years old models simulation. The following image illustrates the model that are being developed for the simulation.

Figure 3 Model for injury modeling (Western University)

Detect and Avoid (3)

Detect and avoid is a mean to reduce air to air collision risk by reactively detecting and avoiding potential collision with other aircrafts (cooperative and non-cooperative).

Initial consultations had generated the following problem statement and unknowns, to solve via research:

- Minimum requirement / means of compliance for DAA systems for BVLOS operations in Canada
- Detect
    - Field of view, volumes(scan vs alert vs operation), range,
    - Safety buffers
- Alert / Decide
- Avoid
    - Automation
    - Rules

Detect and Avoid project with LookNorth

Following the four 2018 BVLOS trials, it was determined that more data on DAA systems should to be collected. The intent was to organize DAA specific trials, where rigorous test protocols could be validated by TC and NRC, in collaboration with participating organizations, in order to assess the performance of the currently available DAA solutions against draft standards. NRC could also structure the data to be recorded and be involved in technical supervision of the trials and especially, analyze the data post-trial, to provide technical recommendations.

Trials are currently scheduled for summer 2020.

RPAS Traffic Management (RTM) (4)

It should be noted that TC and NAV Canada recently launched the RTMAT (RPAS Traffic Management Action Team). TC RPASTF and NRC are members of this working group and are currently identifying required R&D effort.

Separately, a RTM related project is being sponsored by CRIAQ. Below is the project overview available on the CRIAQ website(https://criaq.aero/en/projects/).

"Our solution suite consists of several components that provide specialized features for making automated, semi-automated, or manual UAV operations much safer, while providing authorities and law enforcement bodies with the tools for oversight and control that can guarantee the compliance with their regulatory framework. This modular approach provides great flexibility for deploying customized solutions that can work both as stand-alone modules or integrated solutions. Our technologies are designed and built with a safety-first approach, following aerospace and communication industries best practices.

SafeUTM platform a large-scale software development project, expected to be the first truly complete Canadian UTM (UAS Traffic Management). The SafeUTM platform is expected to support a combination of different features that ensures the safe operations of RPAS, such as Detect and Avoid techniques for different flight scenarios, cross-domain segregated redundant communications (e.g. cellular network, satellite communications, among others) to enhance C2 link robustness, and capability to detect other RPAS (not friendly) in restricted airspace and no restricted airspace.

To achieve the objectives, Savinte has sought expertise from different partners such as Concordia University as the main academic partner and Romaeris Inc. as the primary industrial partner. The goal is to add value, create high fidelity systems, and have the means to verify and validate all of the components in a real life scenario via a flight test program.

Concordia University will work on a sense and avoid algorithm. The objective of this algorithm is to detect and avoid fixed and moving obstacles in real time using sampling of the environment surrounding the vehicle and adaptive flight control laws. The algorithm will be based on rapidly exploring random trees. SafeUTM will integrate technology provided by Concordia University pertaining to detect and avoid techniques. This partnership is expected to create core functions that will be used as part of the flight management functionality provided by SafeUTM. Furthermore, Savinte will be able to leverage from great technical expertise and accelerate development of project.

Leveraging Romaeris expertise in flight operations with their technology, Savinte is planning to create a

flight test program to validate (and eventually certify once regulations allow) the different components of SafeUTM in a real-life scenario, including beyond visual line of sight flights. This way, we provide initial great value to Airspace Regulatory agencies like Transport Canada & Nav Canada, to Airport & Port Authorities, as well as to enterprises making UAV systems (such as Romaeris).”

Icing and extreme weather (5)

Initial consultations had generated the following problem statement and unknowns, to solve via research:

- Icing conditions limitations for each category of UAS
    - Most critical icing conditions for small / medium UAS
    - Effect of icing on small orifices (pitot, static) and other systems (electronics, controls, motors, rotors/propellers)
    - Ice accretion monitoring and effective de-icing
- Detection and avoidance of icing conditions
    - Effect of Micrometeorology on UAS operations (Low altitude)
- Applicability of 14 CFR Appendix C/O icing conditions (To be determined)

In discussions with FAA, and with the intent of leveraging Canada’s expertise in icing, the icing research priority was identified, as typical to Canadian climate.

Icing of small Rotors at High RPM project

Investigation of tolerance for icing for small RPAS rotors and propellers was performed in a project which began with the creation of a fully instrumented test bench.

The tesing phase was performed in fall 2019, and the report is expected in March 2020.

Effect of wind in different environments project

A project is being initiated on the effect of wind and wind gusts in different types of environments (Rural, Suburban and Urban), with the intent of determining safety tolerances for RPAS operations.

Human Factors (6)

There is currently no active project in this research area.

Certification of Autonomous Systems (7)

Initial consultations had generated the following problem statement and unknowns, to solve via research:

- Applicability of existing airworthiness standards, ex:
- Systems Safety analyses and software certification standards may not fit well with artificial intelligence based autonomous systems
- Non-determinism in the decision making process of autonomous algorithms presents an equally challenging topic for certification
- Decomposition of pilot functions and how these functions are implemented into system requirements and performance requirements
- Means of compliance

Certification of Autonomy Project

The certification of autonomous flight systems project has the scope of leveraging the development of a vertical lift autonomy demonstrator to gain insight into the certification considerations applicable to autonomous aircraft. The activities being carried are the following:

- Regulatory gap analysis of certification requirements for increasing levels of autonomy
- Analysis of pilot tasks which could be allocated to an autonomous system
- Analysis of System Safety methodologies for autonomous flight systems
- Analysis of application of JARUS SORA (Modified) to autonomous flight scenario
- Research to measure/quantify trust in automation

Scientific / technical contacts and working groups

The following list provides the reference experts in each sector. Each sector is more or less organized as a working group. In some groups are recurrent meetings, in others the members are consulted when required. It is implied that Carlos Ruella, Enzo Diodati, Matthew Spannos and Charles Vidal are part of each working group.

1- Air to Air collision (Probability)

Iryna Borshchova (NRC)
Kris Ellis (NRC)

Air to Air collision (Severity)

Azzedine Dadouche (NRC)
Mark Espenant (DRDC)
Jackie Yu - TCCA National Aircraft Certification

2- Air to Ground collision probability and severity

Haojie Mao - UWO
Javad Gholipour (NRC)

Manouchehr Nejad (NRC)

3- Detect and Avoid

Kris Ellis – NRC
Iryna Borschova – NRC
Paul McKay - *RPAS TF Engineering*

4- RTM

Iraj Mantegh – NRC
Ryan Johnson, RPAS TF
John Taylor TC - Flight Stds
Craig Bloch-Hansen - RPAS TF Engineering

5- Human Factors

Sion Jennings – NRC
Michel Lambert – NRC
William O'Gorman – TCCA NAC FTE
Louis-David Germain – TCCA NAC FTE
Paul McKay – TCCA RPAS TF Engineering

6- Icing and extreme weather

Ali Benmeddour – NRC
Bill Maynard -TCCA
Antoine Lacroix - TC Innovation Centre
Howard Posluns - TC Innovation Centre
Louis-David Germain – TCCA NAC FTE
David Johns - TCCA NAC Engineering Manager -ECS
Alexi Korolev - EEEC
Eric Fleurent-Wilson – NAC
Alanna Wall – NRC
Hali Barber – NRC
David Orchard - NRC

7- Certification of Autonomy

Derek Gowanlock - NRC

Other research mechanisms

In order to help encourage research to be done by industry and academia, progress was made in establishing calls for proposals with R&D organizations, as presented in this section.

CRIAQ / CARIC

TC and NRC worked with CRIAQ to perform an official call for RPAS projects in the current fiscal year. The objective was to use CRIAQ/CARIC's network, and CRIAQ-CARIC would sponsor projects to be performed

at University and in industry. The research areas proposed by TC-NRC were those in which there was opportunity to complement the research already being performed, namely:

- **BVLOS-1: DAA system qualification:** Provide data on risk mitigation of specific DAA systems to inform regulator and enable issue of BVLOS SFOC.
- **BVLOS-2: C2 link robustness:** Propose architecture to inform the regulatory requirement for Command and Control link characteristics for BVLOS operations in urban and rural area at low altitude (<500feet), by small-medium UAV
- **BVLOS-3: Human injury probability:** Inform regulatory on probability of impact on people, in case mishap BVLOS operations:
- **BVLOS-4: Human injury severity:** Inform on injuries that can be caused by drone impact on people includes cuts, concussions, lesions, fractures, etc.)
- **BVLOS-5: Drone Detection:** Development of an effective and affordable solution for drone detection on critical section of airspace on or in vicinity of airports or aerodromes

In total, 30 Organizations submitted project ideas. An initial technical review of those received projects ideas was performed by a team composed of TC, NRC, NRC IRAP, CRIAQ and CARIC. Depending on the potential for contribution to regulation development, as well as other eligibility criteria, each project was reviewed and redirected towards the optimal agency between CRIAQ and NRC IRAP.

Subsequently to the Call for projects, the CRIAQ qualified organizations, which were seeking partners, were invited to pitch their project Idea at the CRIAQ RDV forum, at the Gesu, in Montreal, On September 17th 2019. This was also an opportunity for TC and NRC to further describe the RPAS call for proposals to the community.

It should be noted that unfortunately, during the year, the CARIC budget was discontinued and CARIC could not sponsor projects. More details regarding this call for projects can be found in appendix 4.

NRC IRAP

Collaboration with the National Research Council-Industrial Research Assistance Program (NRC-IRAP) was significant in the current fiscal year. IRAP Aerospace Sector Team Lead at IRAP were very involved in the CRIAQ/CARIC Call for Proposals.

LookNorth

LookNorth typically sponsors R&D efforts, with calls for proposals, to SME. NRC and TC collaborated with LookNorth to perform a call for proposal to specifically test DAA systems. In 2019, a call for proposal was done by LookNorth. The CFP is presented in appendix 3.

Below are presented the key dates of this second LookNorth CFP:

- Announcement Date for Call for Proposals – September 3rd, 2019
- Proposal (including ConOps) Submission Deadline – October 15th, 2019
- Expected Decision Date of Selected Applicants – December 15th, 2019
- Submission of DAA Test Plan – January 31st, 2020
- Test Readiness Review – No later than March 31st, 2020
- Completion of DAA Testing – Exact testing dates to be coordinated between all stakeholders
- Submission of DAA Test Report – June 30th, 2020

Innovative Solutions Canada (ISC)

This mechanism is being explored for R&D projects. There is an opportunity for TC-NRC to elaborate a technical challenge that would support regulation development. NRC-TC went ahead and began initiating the elaboration of a challenge.

Créneau des drones du Québec

The Quebec drone cluster also supports RPAS R&D projects. This mechanism is still being explored at the time of writing this report.

Integrated Aerial Mobility (IAM) Program at NRC

NRC is initiating a new program in FY19-20, leveraging its experience in RPAS activities, to extend its research activities to also include cargo drones as well as passenger drones (Urban Air Mobility). It is expected that those two additional areas fit within the Next Generation type of RPAS operations, for which the regulatory framework will be tackled after the BVLOS or RTM regulations are complete.

The three high level objectives of the IAM program are:

- Develop and support the development of critical technologies and then qualify them through demonstrations in both virtual and physical domains
- Stimulate the establishment of a sustainable autonomous on-demand UAS industry in Canada through a stronger supply chain
- **Provide knowledge-based support to Transport Canada to enable autonomous operations of UAS in Canadian airspace**

It is understood that there is an advantage for TC to be involved in UAM sooner, as it is an emerging sector, and that there is significant activity in the USA, as FAA and NASA launched the UAM Grand Challenge, and it is expected that UAM platform manufacturers will begin to ask permission to fly in Canada.

Report on progress of RPAS research activities performed during the fiscal year

A Monthly status update meeting is chaired by NRC. The following table presents work/milestones achieved, impact on future research and impact on regulation of the projects.

R&D support Regulation development project list					
Research area	**#**	**Projects**	**Work / Milestones achieved**	**Next Steps**	**Potential Impact on regulations**
Air to Air collision probability and severity	**1.1**	Air Risk Model	Initiating a project	Exploring ways to quantitively evaluate air collision risk	Align risk classes with Canadian airspace traffic
	1.2	Drone Impact Assessment (Drone cannon and impact testing)	Canon Commissionned	Testing to validate numerical model	Information on damage severity and mitigation requirements
Air to Ground collision probability and severity	**2.1**	Human Injury Probability (One project starting under CRIAQ)	Project initiating		
	2.2	Human injury Severity	Injury criteria that encompasses all population (50 percentile male, 5 percentile female) (upcoming)	Develop injury threshold and test / simulation procedures	Understanding of injury severity and mitigation requirements
Detect and Avoid	**3.1**	DAA system testing (In collaboration with LookNorth)	Initiated project through LookNorth	DAA testing	Understanding of state of the art technology performance and limitations
RTM	**4.1**	RTM and C2 (One project starting under CRIAQ)	Project Initiating		
	4.2	RTM Research	Project Initiating		
Icing and extreme weather	**5.1**	Investigation of effect of icing on Small rotors	Tested small rotors at high RPM	Instrumentation and testing of rotors used in drones	Inform icing related limitations
	5.2	Investigation of effect of wind in different environments	Project Initiating		Inform tolerance level in different environments
Human Factors	**6.1**	Enhanced Situation Awareness	Haptic HIL station System demonstration	Completed	Model to assess effect of latency on operation mode.
Certification of Autonomy	**7.1**	Certification of autonomous systems (Bell 412)	-Establishment of working group, Gap analysis	Instrument to perform research being developed	Definition of technological challenges
Planning and coordination	**8.1**	R&D plan development, coordination and update	Coordination of multiple project and initiatives, and with other organizations	Continue coordination of current and expand to new initiatives	-Execution of research projects informing regulations -Creation of working groups of experts -Outreach, international coordination

Table 2 Progress report overview

Major Activities during fiscal year

At the date of writing this report, the following major activities had been performed within this R&D planning and coordination project;

- Recurrent discussions with stakeholders and working groups for each research area
- Multiple meetings with FAA, FAA ASSURE and NASA. TC and NRC have been coordinating with FAA in each research domain, in order to ensure there would be no duplication of effort and also that planned research was relevant to both organisations.
- Discussion with both Canadian Official UAS test sites (Foremost, AB and Alma, QC) to define how the test sites can be used to support the required testing.
- Participation at AUVSI Exponential conference in 2019 to support meetings with stakeholders (FAA, FAA ASSURE, Universities and professors, industry).
- Preparation and launch of CRIAQ Call for Projects, June 2019.
- Preparation and launch of Looknorth Call for Projects, June 2019.
- Presentation of the CRIAQ Call for Projects at CRIAQ RDV Forum, September 2019
- Presentation of the R&D activities, Alma Tech demo, September 2019
- Presentation of the R&D activities, Unmanned Canada 2019 conference, November 2019

- Presentations, FAA International Unmanned Systems Integration Research Roundtable, Washington, September 2019
- Involvement in NASA SIO (System Integration and Operationalization)
- Involvement in FAA-NASA Grand Challenge

Other activities performed

- Discussions with R&D organizations (CRIAQ/CARIC, NSERC, NRC IRAP, etc.).
- Participation in TAAC conference in December 2019
- Participation in 2019 and 2020 Canadian Student UAS competition
- Recurrent monthly meetings TC-NRC-DRDC
- Monthly R&D progress update
- Motor Vehicle Test Centre visit (Blainville, Qc)

Conclusion

The strategic partnership of TC and NRC is becoming fruitful, as there is now a significant research effort being deployed generating scientific data. At the FAA Research International Roundtable, where many countries were present, it was clear that Canada was one of the leaders in this sector.

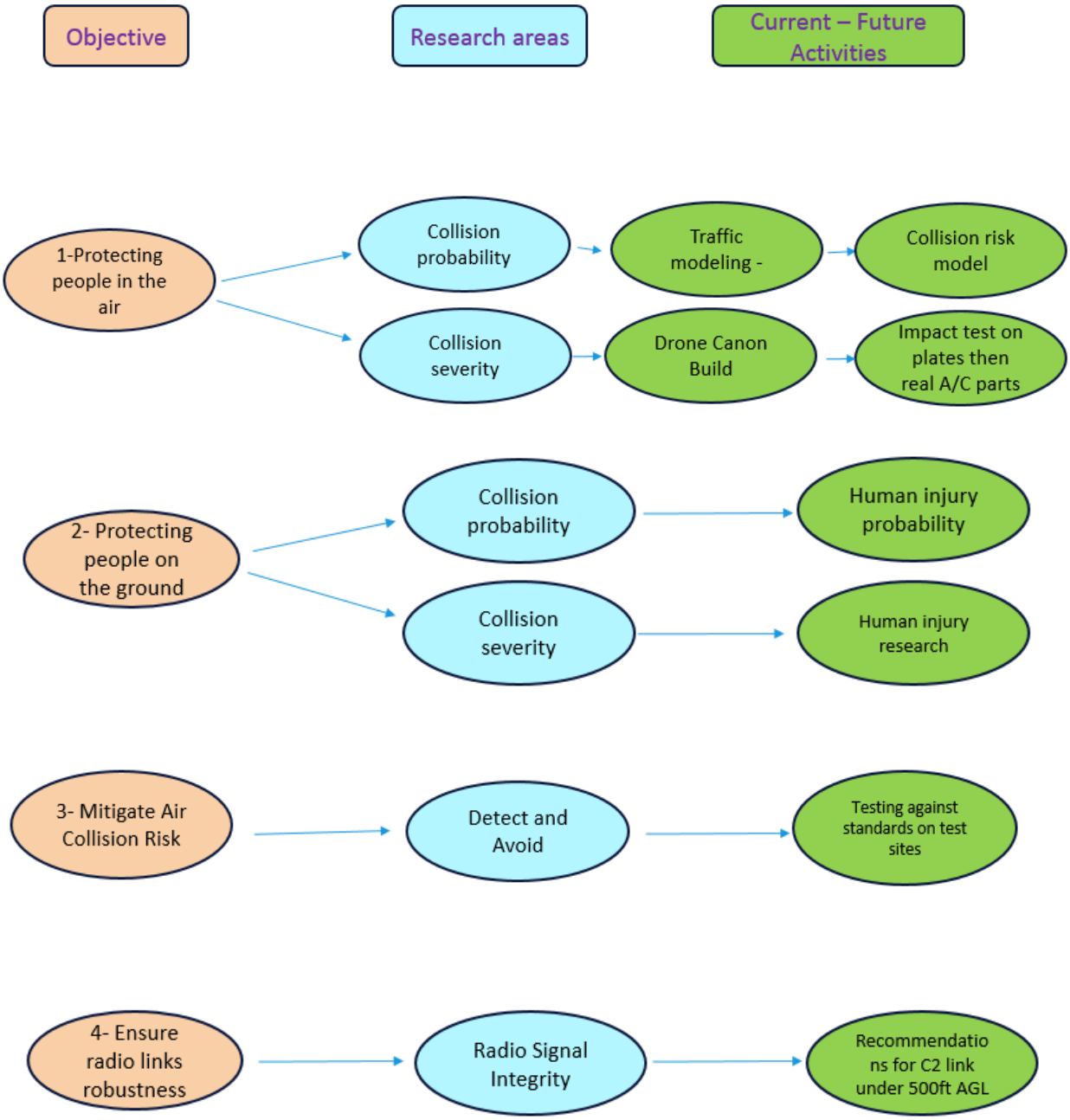
Innovative ways for the regulator to work with Companies and Academia were also put in place, thanks to the collaboration with CRIAQ/CARIC, NRC IRAP and LookNorth.

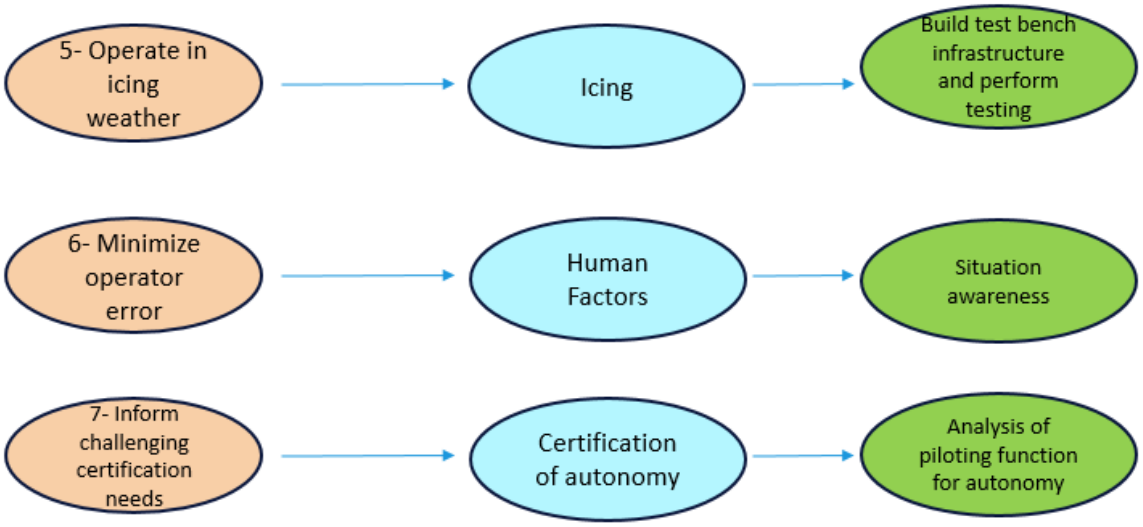
The official launch of the IAM program at NRC will also act as a catalyzer for the sector, enabling technology development in line with regulation development, leading to an increase in collaborations between TC and NRC.

With this strategic governmental alliance, TC can move ahead in the coming years with confidence, knowing that they are providing to Canadians and Canadian industry a flexible regulatory framework that enables investments creating an efficient, environmental friendly, and safe transportation system for all Canadians. FAA, TC and NRC considers that a flexible regulatory framework can be enabled by research plus operations.

This progress report is a living document which main objective is to provide a yearly high level update on the TC-NRC collaborative RPAS research effort. For more details, the reader is invited to consult the report generated by each research project.

Appendix 1 High level original roadmap




5- Operate in icing weather
Icing
Build test bench infrastructure and perform testing
6- Minimize operator error
Human Factors
Situation awareness
7- Inform challenging certification needs
Certification of autonomy
Analysis of piloting function for autonomy

Appendix 2, Core TC-NRC Collaborative R&D team members

Name	**Title**
Félix Meunier	Director RPAS Task Force - Program Sponsor
Enzo Diodati	RPAS Task Force Engineering – Acting Chief
Carlos Ruella	RPAS Task Force Engineering –R&D Project Manager
Ryan Johnson	Program Manager, Operations
Wajid Chishty	IAM Program Lead
Charles Vidal	Research Council Officer
Iraj Mantegh	Senior Research Officer
Derek Gowanlock	Research Council Officer

Appendix 3, LOOKNorth call for proposals

Detect and Avoid Technology Demonstration and Validation in Support of BVLOS Operations

Program Description

Transport Canada in conjunction with the National Research Council of Canada (NRC) has identified several key areas of technology development and demonstration which are necessary to address potential BVLOS safety issues. One of these areas includes assessing RPAS detect and avoid technology capability in order to mitigate risk of mid-air collisions with manned aircraft during BVLOS operations in non-segregated airspace.

LOOKNorth and Unmanned Systems are collaborating with Transport Canada and NRC to assess current Canadian capability in these areas. The approach will be to work with interested companies to plan, execute and evaluate the demonstration of both ground and air based DAA technologies at one of two Canadian test ranges or at another suitable test location (the possibility of undertaking demonstration at an Ottawa location is being investigated).

TC/NRC/LN intend to work with selected companies who have expressed an interest in participating in the demonstration to define company specific tests within a common context that will enable the evaluation of a given technology in addressing SORA or other recognized industry standards with respect to their incorporation of DAA technology in RPAS mission risk assessment.

Participating companies have been pre-identified based on response to an open call for proposals earlier this year as well as general understanding of the Canadian industry activity. Companies have been contacted and after discussing the general concept have either indicated an interest in participating or declined at this time. Only those companies indicating an interest in participating are receiving this invitation.

Scope and Intent

The intent of this call for proposals is to address, Detect and Avoid Systems, one of Transport Canada's Research and Development priority areas with respect to BVLOS technology readiness.

LOOKNorth, Transport Canada and NRC will consider proposals that demonstrate different approaches to DAA (air or ground based – using any suitable type of sensor). It is expected that each company responding to this call will describe their technology and an effective manner for evaluation based on demonstration at either one of Canada's two approved test ranges (Alma or Foremost) or potentially an urban location (such as Ottawa). LOOKNorth is prepared to share costs of undertaking the demonstration so the proposal should include a project budget with sufficient detail to outline both company direct costs as well as those associated with engagement at a test location. LOOKNorth constraints on the types of funding that will be supported are described later in this document.

LOOKNorth funding will only be made available to Canadian SMEs. Respondents may be DAA technology providers or operators of the technology who wish to demonstrate operational capability with a given DAA technology.

Participation in these trials will allow companies to demonstrate the ability of their technology to reduce their operational risk profile. In addition, the data collected during these projects may be used to substantiate the meeting of DAA requirements required for the issuance of future BVLOS SFOCs.

Successful demonstration results will be beneficial in assisting Transport Canada in developing and validating operational and technical DAA performance standards, as well as the associated Means and Methods of compliance related to specific classes of DAA systems.

The precise definition of the demonstration scenario is still to be defined and will be done in collaboration between Transport Canada, NRC, LOOKNorth and the demonstrating companies. It is anticipated that companies should allocate approximately one week at the range (or other location) to complete the demonstration. The exact duration on the range will depend on the complexity of the actual testing being proposed by the applicant as documented in their DAA test plan.

A Concept of Operations (ConOps) will need to be prepared for the specific routine non-segregated operation that the operator is envisioning, or that the manufacturer is intending their DAA system to be used for. This will help to identify the JARUS SORA Air Risk Class (ARC) and hence the level of DAA required as well as the respective performance requirements.

The companies that are selected for the testing phase will be required to prepare a DAA test plan prior to and DAA test report following the testing for review by Transport Canada and NRC. The specific DAA system will be tested at one of the Ranges to compare the performance of the DAA system against the draft standards.

TC and NRC will participate in the technical review of submissions to help select the applicants that will proceed to the testing phase. The exact number of systems selected for testing will be based on a variety of factors, including but not limited to: the quality of proposals, the diversity of approaches, and the amount of funding available to support the proposed demonstrations.

Timing and Preparation

Following is a schedule for preparation, review and approval of demonstration proposals as well as follow dates for demonstration planning and execution.

Proponents are asked to note the following important dates:

- Announcement Date for Call for Proposals – August 30th, 2019
- Proposal (Including ConOps) Submission Deadline – October 15th, 2019
- Expected Decision Date of Selected Applicants – December 15th, 2019
- Submission of DAA Test Plan – January 31st, 2020
- Test Readiness Review – No later than March 31st, 2020
- Completion of DAA Testing – Exact testing dates to be coordinated between all stakeholders
- Submission of DAA Test Report – June 30th, 2020

***Note:** It is the applicant's responsibility to obtain any SFOCs (if required) from Transport Canada to conduct the testing at the range. Completion of the testing will not automatically result in future SFOCs.

The plan will be to formally approve projects by early December with demonstration occurring in early spring.

Companies responding to this request for proposals are free to discuss their approach with LOOKNorth and/or Transport Canada during the preparation stage. Following submission of their proposal, there may be further discussion to clarify and adjust plans as required. Formal development of a test plan and concept of operations will begin after official proposal approval (early December).

Eligibility

Proposals will be accepted from project teams led by Canadian SMEs to help rapidly advance the commercialization of BVLOS operations.

All proposed projects considered for funding must demonstrate a strong commercialization component. BVLOS application trials target technology solutions at a technology readiness level (TRL) in the range of TRL 5 – 7

http://esto.nasa.gov/files/trl_definitions.pdf

Successful proposals should address "benchmarks" for expected and desired outcomes. This should include but not be limited to new products/services, incremental revenue, new employment and investment potential from a successful demonstration.

For BVLOS concepts of operations projects, the following conditions apply:

- LOOKNorth will fund up to 50% of eligible costs, to a maximum of $25,000 of LOOKNorth funds per project.
- Selected SMEs may be eligible for IRAP support, please contact your local ITA or call 1-877-994-4727 for more info
- Detailed cost eligibility guidelines can be found in the CECR program guide at the following link

  http://www.nce-rce.gc.ca/ReportsPublications-rapportsPublications/CECR/Program-Guide-Programme_eng.asp

- Projects should meet the schedule documented below
- All proposed projects considered for funding must demonstrate a strong commercialization opportunity for the proposing company.

General Instructions

Data and Intellectual Property

Any intellectual property developed as a result of a funded project shall belong exclusively to the Proponent. There is however an explicit requirement to share safety case data for the collective benefit of developing evidence-based recommendations to Transport Canada for BVLOS regulations.

- All applicants must agree to make their pre-flight profiling data as well as results of their flight tests, including operational missions, available for input into the testbed and risk evaluation tools.
- All applicants must agree that their results may be shared among Transport Canada/NRC and industry cluster participants.
- Proprietary and commercially sensitive information will remain protected.

Submission Instructions

Interested proponents must complete the proposal template, located here:

https://www.looknorth.org/cms_content/files/files/Investment%20Proposal%20Template%20-%20FIN.pdf.

Full instructions for completing the application are included with the Proposal template.

As well, proponents must complete a preliminary Environmental Assessment Checklist, located here on the LOOKNorth website:

https://www.looknorth.org/cms_content/files/files/LN-EAP&Checklist-Fillable.pdf

Questions or Clarifications

Please submit enquiries and requests for clarifications to Neil Cater – Operations.

Email: dennis.nazarenko@looknorth.org

Tel: (613) 513-5106

About LOOKNorth

LOOKNorth is a Centre of Excellence for Commercialization and Research (under Canada's Networks of Centres of Excellence program), hosted by C-CORE. LOOKNorth's Investment Program fosters and supports innovation in remote sensing technologies and applications, assists Canadian satellite SMEs to define and successfully execute missions relevant to industry and communities, fosters advances in Canada's UAS sector - particularly Beyond Visual Line of Sight (BVLOS) operations, and helps build capacity in remote sensing technologies and services in Canada's North.

LOOKNorth and Unmanned Systems Canada are partnering to build a national cluster of industry and academia to develop the Remotely Piloted Aerial Systems (RPAS) industry in Canada, with a focus on accelerating the commercialization of RPAS-based beyond visual line of sight (BVLOS) remote sensing applications.

LOOKNorth/USC have established a national testbed to collect relevant performance data from flight trials and to evaluate these data using a common risk assessment tool. This national testbed is intended to promote collaboration amongst Canadian companies to create and utilize a common risk model for all flight trials. Over time, the aggregation of data collected during these flight trials as well as the resulting analyses will support evidence-based recommendations to Transport Canada to support development of BVLOS regulations. Ultimately, the process will drive the development of new markets, attract investment and improve the competitive position of Canadian companies in a global marketplace.

Appendix 4, CRIAQ/CARIC RPAS Call for proposals

The National Research Council (NRC) is collaborating with Transport Canada (TC) to develop a 5-year R&D plan to support regulatory development for visual line-of-sight (VLOS)/beyond visual-line-of-sight (BVLOS) remotely piloted aircraft systems (RPAS) operations and to identify technology advancements, testing and certification that will enable safe operation of RPAS (also known as drone, UAS or UAV) in Canada. The objectives are to develop and oversee the Government of Canada's transportation policies and programs so that Canadians can have access to a transportation system that is safe and secure; green and innovative; and efficient.

The Consortium for Aerospace Research and Innovation in Canada (CARIC) and the Consortium for Research and Innovation in Quebec (CRIAQ) will support Transport Canada and NRC to deploy a RPAS R&D Program, by making use of their networks with the objective to:

Stimulate, Create and Support opportunities for industry, academia and government to perform **collaborative research activities** to support Canadian regulatory framework development

Support other key initiatives when required

In this context, a call for projects ideas is launched in the following themes:

BVLOS-1: Detect and Avoid (DAA) system qualification: Provide data on risk mitigation of specific detect-and-avoid (DAA) systems to inform the regulator and support the issuance of BVLOS Special Flight Operations Certificates (SFOC).

BVLOS-2: C2 link robustness: Inform the regulatory requirement for Command and Control (C2) link characteristics for BVLOS operations at low altitude (<500feet), by small-medium RPAS.

BVLOS-3: Human injury probability: Inform the regulatory requirement on probability of impact of the RPAS on people, in case of mishap for BVLOS operations at low altitude, by small-medium RPAS.

BVLOS-4: Human injury severity: Inform on injuries that can be caused by RPAS impact on people (Not limited to 50th percentile male, includes cuts, concussions, lesions, fractures, etc.) and efficiency of mitigation factors.

BVLOS-5: Drone Detection: Development of an effective solution for RPAS detection on critical section of airspace on or in vicinity of airports or aerodromes

Goals of this program include development of technological breakthroughs and new enabling technologies, with significant economic benefit for Canada (jobs, revenues, etc.).

Interested industrial partners are invited to submit a project idea with research partners for the development of collaborative projects for this RPAS specific call.

Eligibility criteria:

Projects must address one of the above listed topics

Industry partner(s) must have an R&D presence and/or manufacturing facility in Canada, and the operations in Canada must be expected to commercialize the R&D results of the project

Intellectual Property (IP) arising from the project will be managed by the project participants, as CARIC-CRIAQ does not claim or manage IP rights.

Available Funding*:

Available Funding*:

Funding agency	Location	TRL	Funding recipients	Public funding support
CRIAQ	Provincial – Quebec* *funding recipients must be in QC but partners outside of QC are eligible	2-4	Research organizations (universities, colleges, research centres)	Maximum 40% of project eligible expenditures
		4+	Industries + Research organizations (universities, colleges, research centres)	Maximum 50% of project eligible expenditures
IRAP	All provinces	4+	SME	Maximum 80% of salaries of employees Maximum 50% of salaries of sub-contactors
NSERC	All provinces	2-4	Research organizations (universities, colleges, research centres)	Maximum 50% if OEM + Research organizations Maximum 66% if SME + Research organizations or SME + OEM + Research organizations

** Not exhaustive. Access to funding is submitted to programs eligibility criteria – a representant from the relevant program will be in contact with you after your idea submission.*

Average value of a project: 500k

Average of project duration: 1,5 to 3 Years

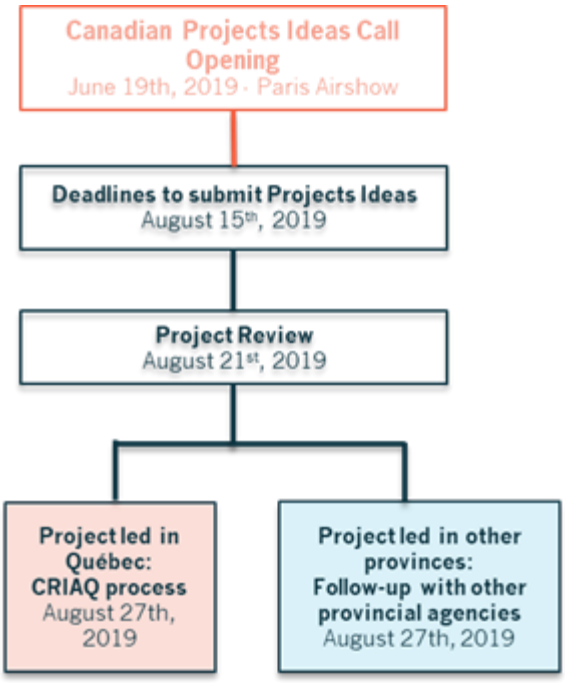
Submission process:

Download the template

Deadline to submit project ideas: August 15th, 2019 at the following address: project@caric.aero

For more information, please contact project@caric.aero

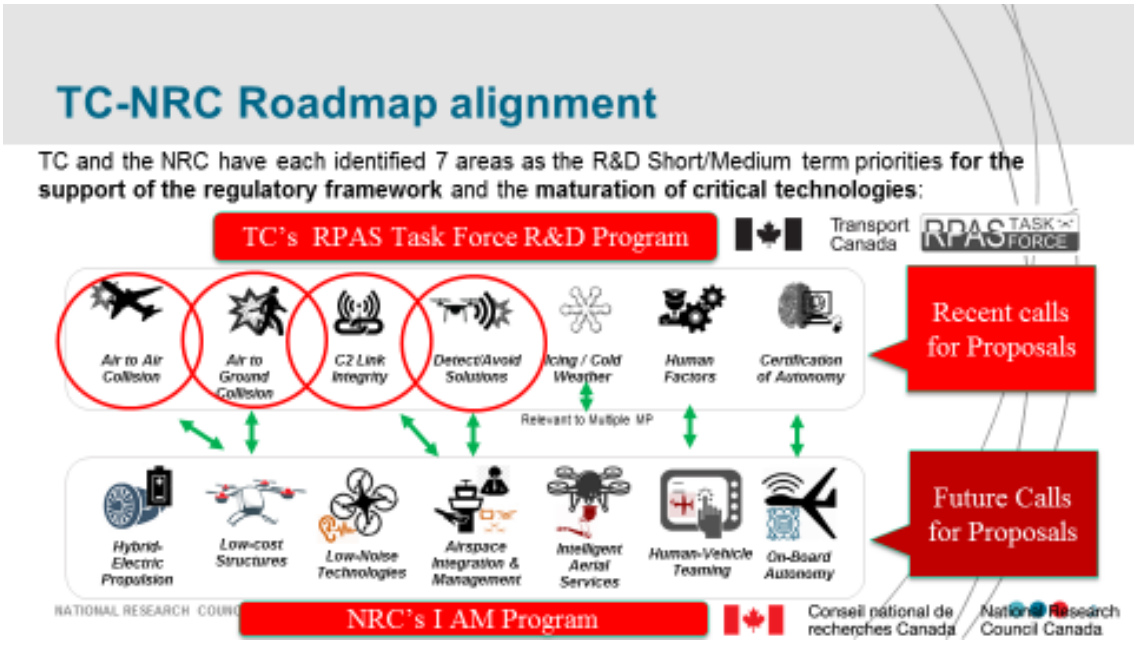
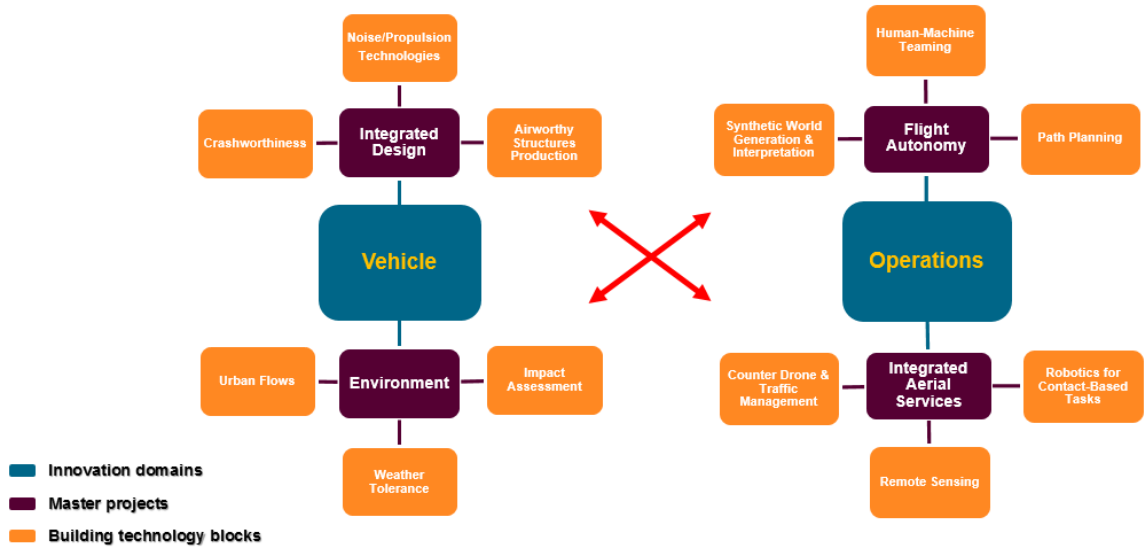
Timeline:



CARIC will act the point of contact for the reception of the project ideas and the coordination of the initiative. All the project ideas will be therefore evaluated by a joint committee including representatives from CARIC, CRIAQ, NRC and TC.

All projects led in Québec, dealing with technology readiness level (TRL) level from 2 to 6 and meeting CRIAQ eligible criteria will be invited to follow the CRIAQ process.

Appendix 5, NRC-TC collaborative research and IAM presentation



IAM Program Structure